

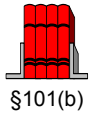
8 **Special Compliance Topics**

This chapter discusses special topics as they apply to the various compliance paths for the *Energy Efficiency Standards (Standards)*. For a discussion of other special topics not covered in this chapter, see Appendix G (*Glossary*). The special topics addressed in this chapter include:

- Multi-Family Buildings. Compliance of the building as a whole or unit-by-unit.
- Mixed Occupancy Buildings. Compliance of the dominant occupancy alone or each occupancy separately, and how mandatory measures apply.
- Subdivisions And Master Plans. Multiple orientations of the same plan.
- Fenestration Products (Glazing). An explanation of glazing terminology and the thermal performance rating system for all fenestration products.
- Wood Space Heating. A description of compliance for wood heat and installation criteria.
- Controlled Ventilation Crawl Space (CVC). An explanation of the procedure for analyzing the energy use, as well as a listing of installation requirements, for CVC.
- Zonal Control. A description of the procedure for analyzing the energy use of zonally controlled space conditioning, as well as eligibility and installation criteria.
- Hydronic/Combined Hydronic Space Heating. An overview of hydronic space-heating systems and compliance calculations.
- Evaporative Cooling. A description of the energy credit for evaporative cooling, as well as eligibility and installation criteria.
- Geothermal (Ground Source) Heat Pump. A description of this type of space conditioning equipment along with efficiency information needed for complying with the *Standards*.
- Log Homes. An overview of the unique aspects of log homes, and how their special features can be accounted for in demonstrating compliance.
- Straw Bale Construction. An overview of the unique aspects of straw bale construction, and how its special features can be accounted for in demonstrating compliance.
- Radiant Barriers. A description of the energy credit for radiant barriers, as well as a listing of eligibility and installation requirements.

8.1 Multi-Family Buildings

In a multi-family building, one dwelling unit shares a common wall and/or floor or ceiling with at least one other dwelling unit. The information contained in this *Residential Manual* applies only to low-rise multi-family buildings. See definitions below.



§101(b)

The following are definitions from §101 of the standard.

HABITABLE STORY is a story that contains space in which humans may work or live in reasonable comfort, and that has at least 50 percent of its volume above grade.

HIGH-RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel, of occupancy group R-1 with four or more habitable stories.

LOW-RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel, that is of occupancy group R-1 and is three stories or less, or that is of occupancy group R-3.



Multi-family apartment buildings with four or more habitable stories (and hotels or motels of any number of stories) are covered by the nonresidential standards. These are explained in the Nonresidential Manual, which is available from www.energy.ca.gov/title24. Multi-family buildings with one to three habitable stories are considered low-rise residential buildings and are discussed in this *Manual*. See Table 1-4 for a listing of buildings within the scope of the low-rise residential standards, including occupancy group R-2 and congregate residences.

Since there are different standards that apply to low-rise multi-family and high-rise multi-family buildings, it is important to first verify the number of habitable stories in the building. Only those habitable stories that have more than half of their volume above grade should be counted in determining the number of habitable stories, and all conditioned space should be accounted for.

Compliance for a low-rise multi-family building may be demonstrated either for the building as a whole or on a unit-by-unit basis. Walls between dwelling units are considered to have no heat transfer, and may be ignored in performance calculations.

Whole Building Compliance

The simplest approach to compliance for a multi-family building is to treat the building as a whole, using any of the compliance paths described in earlier chapters. In practice, this process is similar to analyzing a single-family residence except for some differences in water-heating budgets explained in Chapter 6. Some of the modeling assumptions used in performance calculations are also different, in particular internal gains from lights, people, appliances, etc.

Compliance Unit-By-Unit

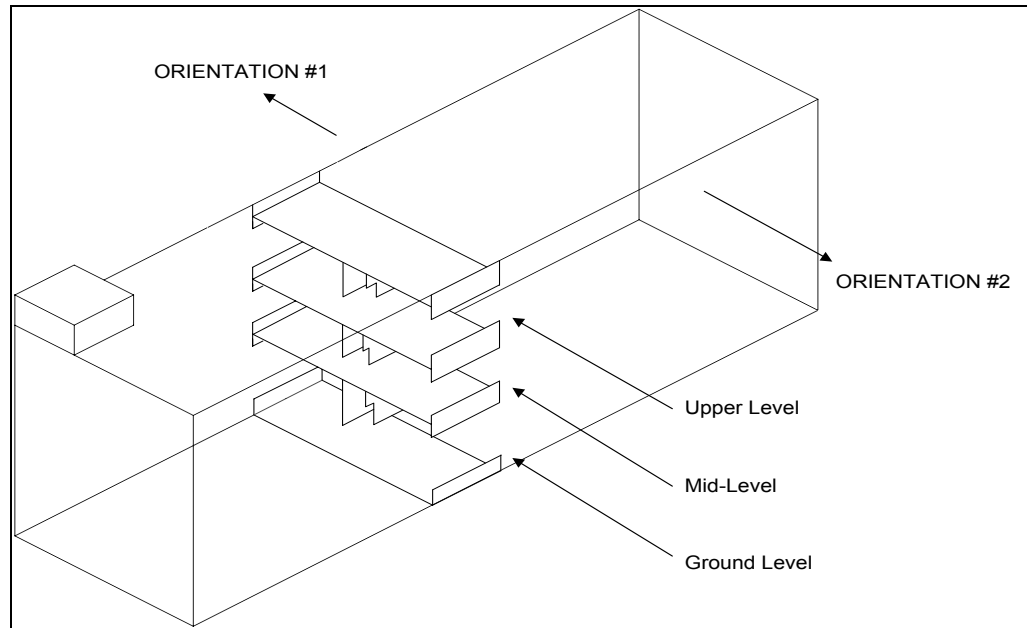
The other compliance approach for multi-family buildings is to demonstrate that each dwelling unit complies separately. Each unique unit in the building determined by orientation and floor level must be separately modeled using an approved computer program. In this approach, surfaces, which separate dwelling units, may be ignored as they are assumed to have no heat loss or heat gain associated with them.

Different orientations and locations of each unit type within the building must be considered separately. That is, a one-bedroom apartment on the ground floor of a three-story building is different from the same plan on a middle floor or the top floor, even if all apartments have the same orientation and are otherwise identical. With this approach every unit of the building must comply with the standard, so this approach is more stringent than modeling the building as a whole (see Figure 8-1).

Other options for showing unit-by-unit compliance are similar to those for subdivisions and are explained in Section 8.3 of this chapter.

Figure 8-1 – Multi-Family Building Compliance Option

Demonstrate Compliance for Each Generic Unit Type in Each of its Characteristic Locations



Example 8-1 – Multi-Family Building Compliance, Examples

Question

When preparing compliance calculations for a three-story apartment complex, I have the option of showing compliance for each dwelling unit or for the entire building. If I use the individual dwelling unit approach, do I need to provide calculations for every dwelling unit?

Answer

Each dwelling unit must comply with the *Standards* when using this approach. When dwelling units have identical conditions the calculations can be combined. This means you will show separate compliance for all unique conditions, such as:

- Front facing North
- Front facing West
- Front/side walls facing East and North
- Front/side walls facing East and South
- Exterior roof, no exterior floor
- Exterior floor, no exterior roof

Surfaces separating two conditioned spaces (such as common walls) have little heat transfer and can be disregarded in the compliance calculations. Alternatively, you can model the entire building.

*Example 8-2 –
Multi-Family
Building Duct
Testing*

Question

How does the sampling procedure for diagnostic testing for air distribution ducts apply to multi family buildings?

Answer

The simplest approach is to not do sampling. In this case, the duct system associated with every HVAC unit in every multi-family building would be tested.

If the builder chooses to do sampling, then the sampling is done on a whole building basis (consistent with how compliance documentation is done). Under sampling, first a determination needs to be made of how many different types of buildings there are in the development. If every building is different, then sampling doesn't apply and every duct system associated with every HVAC unit in every building in the development has to be tested.

If some buildings are identical, then sampling can be done. For the buildings that are identical, the first of each "model" must be tested. In this building, the duct system associated with every HVAC unit in this building must be tested. After that a sample of the remaining buildings must be tested, according to the procedure in Section 4.4.4. In a building that is to be tested in sampling, the duct system associated with every HVAC unit in that building must be tested. No duct systems have to be tested in buildings that are not selected for sampling. In other words this is a sampling of whole buildings not a sampling of dwelling units within buildings. (Hypothetically, sampling of dwelling units could be done if compliance is shown separately for every dwelling unit in a building.)

Testing must be done on every duct system in a building regardless of whether it appears that the HVAC and duct system are in conditioned space or not. This is akin to a single family residence with one HVAC unit serving upstairs with ducts in the attic and another serving downstairs with ducts between floors. For this single-family counterpart case, both duct systems must be tested to get the duct sealing compliance credit.

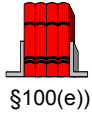
The duct pressurization test has no way to determine if leakage is to outside or to inside. So, through this T-24 test there is no way to determine if the "plenum" which contains the ducts communicates to outside or not.

Also, "inside" and "outside" for leakage purposes is not defined by the locations of walls or the number of stories. The boundary between inside and outside for leakage purposes, is defined by the air boundary, typically drywall, between inside and outside. Spaces between floors and spaces in walls (including interior walls) are often "outside" from a air leakage perspective because they are not sealed effectively to form an air barrier and communicate to the outside.

Duct insulation is not required for ducts in conditioned space because there is an expectation that there will be reduced conduction losses for these ducts. But to get full credit for ducts in conditioned space, duct leakage must be tested and meet the requirements for duct sealing. In a multi-family building in order for compliance credit to be taken for ducts in conditioned space, all of the duct systems in the building must be in conditioned space unless compliance is documented for each dwelling unit separately.

To meet the mandatory requirements all HVAC units must have ducts made of UL 181 approved materials (i.e., cased coils). Coils enclosed by sheetrock do not meet the mandatory requirements.

8.2 Mixed Occupancy Buildings



When a building is designed and constructed for more than one type of occupancy, the space for each occupancy shall meet the provisions of Title 24, Part 6 applicable to that occupancy.

EXCEPTION to Section 100(e): If one occupancy constitutes at least 90 percent of the conditioned floor area of the building, the entire building may comply with the provisions of Title 24, Part 6 applicable to that occupancy, provided that the applicable mandatory measures in Sections 110 through 139, and 150, are met for each occupancy.



Some residential buildings have areas of other occupancies, such as retail or office, in the same building. An example of this might be a three-story building with two floors of apartments above ground floor shops and offices. The first thing to consider when analyzing the energy compliance of a mixed occupancy building is the type and area of each occupancy type.

Depending on the area of the different occupancies, you may be able to demonstrate energy compliance as if the whole building is residential (the mandatory measures of the actual occupancy still apply). This is allowed if the residential occupancy accounts for greater than 90% of the conditioned floor area of the building (or permitted space).

Note: Mandatory measures apply separately to each occupancy type regardless of the compliance approach used. For example, if complying under the mixed occupancy exception, both residential documentation (MF-1R form) and nonresidential documentation for mandatory measures must be submitted with other compliance documentation.

If the building design does not fit the criteria described above for a dominant occupancy, then each occupancy type must be shown to comply on its own. This may be done by using any of the approved prescriptive or performance methods available for each occupancy type. As a result, documentation for each occupancy type must also be considered separately, and a Certificate of Compliance must be submitted for each occupancy type.

8.3 Subdivisions And Master Plans

8.3.1 Compliance Requirements

Subdivisions often require a special approach to energy compliance, since they generally include one or more basic building or unit plans repeated in a variety of orientations. The basic floor plans, *as drawn*, may also be used in a mirror image or *reversed* configuration.

There are two compliance options for subdivisions. They are:

- Model each individual building, or building condition, separately according to its actual orientation.
- Model all four cardinal orientations for each building or plan type with identical conservation features for no orientation restrictions.

Note: The effective date of the 2001 *Standards* is June 1, 2001. Building energy efficiency standards compliance documentation submitted prior to June 1, 2001 using the

multiple Orientation Alternative of §151 (c) shall be used to determine compliance through December 31, 2001.

8.3.2 Individual Building Approach



The most straightforward compliance option for subdivisions is to analyze each individual building in the project separately using any compliance method. This may be practical for subdivisions with only custom buildings, or with only one or two specific orientations for each building plan. This approach requires that each unit comply separately, with separate documentation submitted for each unit plan in the orientation in which it will be constructed.

8.3.3 Multiple Orientation Alternative: No Orientation Restrictions



§151(c)

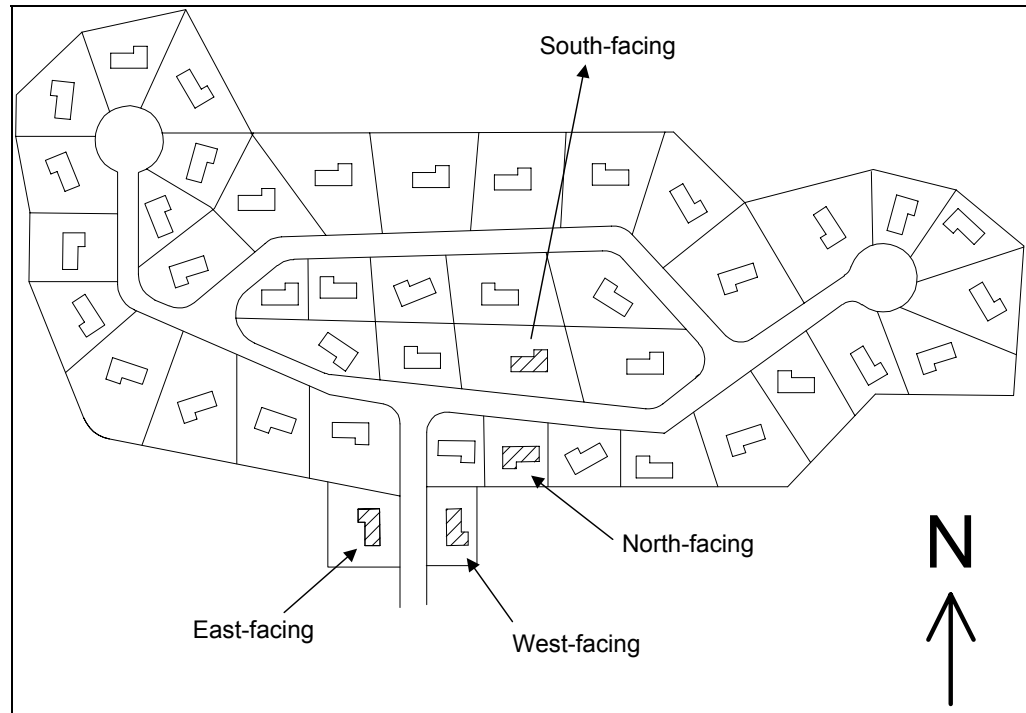
MULTIPLE ORIENTATION ALTERNATIVE to §151(c): A permit applicant may demonstrate compliance with the energy budget requirements of §151(a) and (b) for any orientation of the same building model, if the documentation demonstrates that the building model with its proposed designs and features would comply in each of the four cardinal orientations.

The computer method may be used to demonstrate that a single family dwelling plan or a unit plan in a multi-family building complies regardless of how it is oriented within the same climate zone (Figure 8-2). To assure compliance in any orientation, the annual energy consumption must be calculated in each of the four cardinal orientations: true north, true east, true south and true west. With this option, the buildings must have the identical combination of conservation measures and levels in each orientation and comply with the energy budget in each case.

If a building floor plan is reversed, either the original plans or the reversed plans may be shown to comply in all four cardinal orientations. Multi-family buildings may be analyzed as a whole building using this method or on a unit-by-unit approach at the option of the permit applicant.

**Figure 8-2 –
Subdivisions and
Master Plans
Compliance
Option**

*Demonstrate
Compliance for Each
Cardinal Orientation for
Each Basic Model
Type*



For compliance, submit documentation of the energy budgets for each of the four orientations. In some cases this documentation will be four C-2Rs, while some computer programs generate this information on one form. Only one CF-1R form is required.

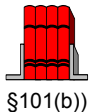
**Example 8-3 –
Multiple
Orientations**

A single-family unit plan in Climate Zone 3 has been calculated by an approved computer method to have an energy budget of 27.89 kBtu/ft²-yr. The proposed design is modeled in all four orientations and no variation in any conservation measure. The following predicted energy use is calculated:

Front North	= 24.65 kBtu/ft ² -yr
Front East	= 26.41 kBtu/ft ² -yr
Front South	= 27.07 kBtu/ft ² -yr
Front West	= 27.83 kBtu/ft ² -yr

Since the energy consumption is less than 27.89 kBtu/ft²-yr in all cases, the unit plan may be constructed in any orientation within Climate Zone 3.

8.4 Fenestration Products



The following definitions are from §101 of the *Standards*.

DUAL-GLAZED GREENHOUSE WINDOWS are a type of dual-glazed fenestration product which adds conditioned volume but not conditioned floor area to a building.

EXTERIOR DOOR is a door through an exterior partition that is opaque or has a glazed area that is less than or equal to one-half of the door area. Doors with a glazed area of more than one-half of the door area are treated as a fenestration product.

FENESTRATION PRODUCT is any transparent or translucent material plus any sash, frame, mullions, and dividers, in the envelope of a building, including, but not limited to:

windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one-half of the door area.

SKYLIGHT is glazing having a slope less than 60 degrees from the horizontal with conditioned space below.

SOLAR HEAT GAIN COEFFICIENT (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

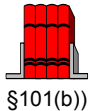
WINDOW is glazing that is not a skylight.



Below is a discussion of how fenestration works, how features of the product affect its rated efficiencies (U-factor and SHGC), terminology and general compliance information. In addition:

- Certification, labeling and mandatory requirements for fenestration products are included in Chapter 2.
- Additions and alterations compliance issues related to fenestration are discussed in Chapter 7.
- Fenestration topics related to prescriptive and computer compliance are found in Chapters 3 and 5.

8.4.1 Fenestration Categories



There are three main categories of fenestration products – field-fabricated fenestration, manufactured fenestration, and site-built fenestration. The following definitions of fenestration categories are from §101(b) of the *Standards*:

FIELD-FABRICATED FENESTRATION PRODUCT [OR EXTERIOR DOOR] is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked-down products, sunspace kits, and curtain walls).

MANUFACTURED FENESTRATION PRODUCT is a fenestration product typically assembled before delivery to a job site. A “knocked-down” or partially assembled product sold as a fenestration product must be considered a manufactured fenestration product and meet the rating and labeling requirements for manufactured fenestration products.

SITE-ASSEMBLED FENESTRATION includes both field-fabricated fenestration and site-built fenestration.

SITE-BUILT FENESTRATION PRODUCTS are fenestration products designed to be field glazed or field assembled units comprised of specified framing and glazing components. Site-built fenestration is eligible for certification under NFRC 100-SB, and may include both vertical glazing and horizontal glazing.

8.4.2 Energy Impact



Windows, glazed doors and skylights have a significant impact on energy use in a home. They account for up to 50% of residential space-conditioning energy. The size, orientation and types of installed fenestration products can dramatically affect the overall energy performance of a house. If designed properly, windows can add heat to a space in the winter, lowering heating bills.

Fenestration products can be responsible for up to 50% of heat loss in the winter and up to 50% of the heat gain in the summer. The U-factor and the SHGC both contribute to maintaining overall thermal comfort and energy performance throughout the year. Properly operating shading year round curtains heat gain in the summer, but reduces the need for heating in the winter. Likewise, the U-factor is important in reducing conductive heat gain in hot climates.

Fenestration performance is related to U-factor and SHGC:

- U-factor is a measure of how much heat travels through a fenestration product. *The lower the U-factor, the more energy efficient the product.*
- SHGC is a measure of the relative amount of heat gain from sunlight that passes through a fenestration product. *The lower the SHGC, the better fenestration is able to keep out solar radiation. The higher the SHGC, the better the window fenestration is able to let in solar radiation.*

The U-factor and the SHGC both contribute to winter and summer overall thermal comfort and energy performance. Several parameters control the performance of fenestration products. These include:

- Frame materials, design and configuration (including cross-sectional characteristics)
- Number of panes of glazing
- Gap width (i.e., the distance between panes)
- Window type (i.e., casement versus double hung)
- Glass surface coatings and/or films
- Gas infill type (i.e., type of gas filling the space between panes of glass)
- Spacer material (i.e., the type of material separating multiple panes of glass)

Fenestration is usually framed in wood, aluminum, vinyl or composites of these. Frame materials such as wood and vinyl are better insulators than metal. Some aluminum-framed units have thermal breaks that reduce the conductive heat transfer through the framing element as compared with similar units that have no such conductive thermal barriers.

Dual glazing offers opportunities for improving performance beyond the dimension of the air space between panes. For example, special materials that reduce emissivity of the surfaces facing the air space, including so-called low-e (low-emissivity) or other coatings, improve the thermal performance of fenestration products through the glass. Fill gases other than dry air – such as carbon dioxide, argon or krypton – also improve thermal performance.

8.4.3 Fenestration Terms



The following is a brief description of some common terms associated with fenestration products:

Center of Glass U-factor: The U-factor measured only through the glass more than 2.5 inches from dividers or the edge of the glass.

Dividers (Muntins): Elements that actually or visually divide different lites of glass. These may be true divided lites, between the panes, and/or applied to the exterior or interior of the glazing.

Edge of Glass: The area of glazing within 2.5 inches of the spacer.

Frame Types:

- **Thermal Break:** Metal frames that are not solid metal from the inside to the outside, but are separated in the middle by a material, usually vinyl, with a significantly lower conductivity.
- **Non-metal:** Vinyl, Wood or Fiberglass. Vinyl is a polyvinyl chloride (PVC) compound used for frame and divider elements with a significantly lower conductivity than metal and a similar conductivity to wood. Fiberglass has similar thermal characteristics.

Gap Width: The distance between glazings in multi-glazed systems (e.g., dual or triple glazing). This dimension is measured from inside surface to inside surface. Some manufacturers may report "overall" IG unit width which is measured from outside surface to outside surface.

Gas Infill: Air, argon, krypton, carbon dioxide, SF6 or a mixture of these gases, placed in the space between the panes of dual or triple glazing.

Grilles: See Dividers.

IG Unit: Insulating glass unit. An IG unit includes the glazings, spacer(s), films (if any), gas infills and edge caulking.

Lights or Lites: a layer of glazing material, especially in a multi-layered IG unit.

Low E Coating (low emissivity metallic coating): A transparent metallic coating applied to glazing that reduces its emissivity, and therefore improves its thermal performance. Low E glazing has a better (lower) U-factor than standard glazing. Many low-e coatings also lower the SHGC. Types of Low E coatings include:

- **Soft Coat:** A sputter applied coating sprayed on at a high temperature. These coatings are usually susceptible to degradation (i.e., oxidation) from contact through handling and storing, but generally provide a lower emissivity, and therefore better thermal performance, than hard coatings.
- **Hard Coat:** Low emissivity metallic coatings applied pyrolytically at or near the melting point of the glass so that it bonds with the surface layer of glass. Hard coatings are not subject to oxidation or scratching as the soft coatings are, and new hard coat technologies provide performance very close to that of the soft coatings.

Mullion: Vertical framing member separating adjoining windows or doors.

Muntins: See Divider.

Spacer: A material that separates multiple panes of glass in an insulating glass unit. Types of spacers include:

- **Aluminum:** Metal channel that is used either against the glass (sealed along the outside edge of the insulated glass unit), or separated from the glass by one or more beads of sealant.
- **"Insulating":** Non-metallic, fairly non-conductive materials, usually rubber compounds.
- **Others:** Wood, fiberglass and composites.

Suspended Films: Plastic films, stretched between the elements of the spacers between panes of glazing, which act as radiant reflectors to slow the heat loss from the interior to the exterior.

8.4.4 U-factor Certification



The U-factor is the total amount of heat that flows through a fenestration product at a given difference in temperature between the interior and exterior surfaces, including the frame, edge of glass and muntins, in Btu/hr-ft²-°F. As required by §116 of the *Standards*, there are two procedures for establishing the U-factor of fenestration products:

- The National Fenestration Rating Council NFRC-100-91 (1991) or NFRC 100 (1997); or
- Default U-factors (see Table 2-2).

Estimating the rate of heat transfer through framing elements of a fenestration product is complicated by the variety of frame configurations for operable windows, the different combinations of materials used for sash and frames, and the difference in sizes available in various applications. The NFRC rating system makes the differences uniform, so that an entire fenestration product line is assumed to have only two typical sizes, one for residential and one for nonresidential. The NFRC rated U-factor may be obtained from a directory of certified fenestration products, directly from a manufacturer's listing in product literature, or from the product label.

Note: Each general type of fenestration product (e.g., double wood-frame Low-E or double metal-frame thermal break) has within it a wide range of U-factors. Therefore, it is impossible to predict the U-factor of a specific product without obtaining the NFRC U-factor rating. Consult the NFRC's fenestration product directory or the manufacturers listed NFRC U-factor ratings carefully when selecting a U-factor to use in compliance calculations.

8.4.5 U-factor for Product Specification Compliance/ Plan Check



When performing compliance calculations and preparing documentation, consult a directory of fenestration products which contains the certified U-factor ratings. One such directory is available from NFRC.

If the exact make and model number of the fenestration products to be installed is not known, there are a few options:

- Look up the U-factors for a number of the products most likely to be installed, and use the highest value of those products. Whichever fenestration product is then installed will comply with the U-factor used in the calculation.
- Specify a particular product and state "or equivalent." In this approach, the builder or installer must understand that the U-factor of the installed product must match, or be less than, the U-factor specified in the compliance documentation.
- Use the appropriate default U-factor from Table 1-D of §116 of the *Standards* (see Chapter 2). The disadvantages of this approach are that:
 - (a) There is no guarantee that a selected product will have the same or better performance than the U-factor assigned to that generic type; or,
 - (b) The U-factor in the table may be much higher than the actual installed U-factor so that additional efficiency measures may be required for compliance.

8.4.6 SHGC Certification



The SHGC is the measure of how well a fenestration product limits solar heat gain entering the space through the fenestration. This value includes the effects of the frame which also effect how much solar heat enters the building.

As required by §116 of the *Standards*, there are two procedures for establishing the SHGC of fenestration products:

- The National Fenestration Rating Council NFRC 200 (1995); or,
- Default SHGC values (see Chapter 2).

SHGC values are between 0 and almost 1, with 1.00 representing no ability to limit solar heat gain. The lower the SHGC, the less solar heat is transmitted through the fenestration product.

For a full explanation of shading, SHGC and shading calculations including the effects of framing divider factors, interior blinds and exterior sunscreens, see *Shading* in the *Glossary*.

Note: Low-e coatings lower the SHGC in addition to reducing heat loss, but there is no direct relationship between emissivity and SHGC. For example, a dual glazed unit with an emissivity of 0.22 may have an SHGC of 0.73 – nearly identical to clear dual glazing - or it may have an SHGC of 0.60, much lower than clear dual glazing.

8.4.7 SHGC Specification Compliance/ Plan Check



When performing compliance calculations and preparing documentation, consult a directory of fenestration products that contains the certified SHGC ratings. One such directory is available from NFRC.

If the exact make and model number of the fenestration products to be installed is not known, there are a few options:

- For those climate zones that have an SHGC requirement of 0.40 look up the SHGC value for a number of products most likely to be installed, and use the highest value of those products. Whichever fenestration product is then installed will comply with the SHGC value used in the calculation.
- Specify a particular product and state "or equivalent." In this approach, the builder or installer must understand that the SHGC value of the installed product must match or be less than the SHGC value specified in the compliance documentation.
- Use the appropriate default SHGC value from Table 1-E of §116 of the *Standards* (see Chapter 2). The disadvantages of this approach are that:
 - There is no guarantee that a selected product will have the same or better performance than the SHGC assigned to that generic type; or,
 - The SHGC value in the table may be much higher than the actual installed SHGC. This may cause the actual energy use to be either higher or lower, depending on climate and the interaction of the fenestration shading with overhangs and building orientation, and may result in additional efficiency measures being required for compliance.

8.4.8 Fenestration Products Construction



The fenestration product installer needs to understand the required U-factors and product SHGC values for the specific project, based on the compliance documentation such as the Certificate of Compliance (CF-1R). The installer should check the documentation to insure that the products have the temporary label on the center of the glazing which meets the compliance requirements.

The U-factor for compliance with the residential standards is the "AA" size. Make sure the "AA" size U-factor is the same as, or less than, the U-factor used in the compliance

documentation. The temporary label must remain on the product until the field inspector has inspected it.

See Chapter 1 for a complete discussion of Installation Certificate (CF-6R form) and the responsibility for completing this form as required by §10-103 (Administrative Regulations)

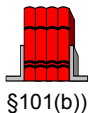
8.4.9 Bay Windows

Bay windows may either have a unit NFRC rating (i.e. the rating covers both the window and all opaque areas of the bay window), an NFRC rating for the window only, or no NFRC rating. Non-rated bay windows may or may not have factory-installed insulation.

For bay windows that come with an NFRC rating for the entire unit determine compliance based on the rough opening area of the entire unit, applying the NFRC U-factor and SHGC. If the unit U-factor and SHGC do not meet the Package requirements, the project must show compliance using the Performance approach.

Bay windows that do not come with a rating for the entire unit (where there are multiple windows to make up the bay), and come with factory installed, or field installed, insulation must comply accounting for the performance characteristics of each component separately. Opaque portions must meet the Mandatory Measures minimum insulation requirements (i.e. R-19 ceiling, R-13 walls, R-13 floor). For prescriptive compliance, the opaque portion must either meet the minimum insulation requirements of the Packages for the applicable climate zone or be included in a weighted average U-factor calculation of an overall opaque assembly that does meet the Package requirements. For the windows, the U-factor and SHGC values may be determined either from an NFRC rating, or by using default values. If the window U-factor and SHGC meet the Package requirements, the bay window complies prescriptively (if overall building fenestration area meets prescriptive compliance requirements). Bay window fenestration area is based on each individual window in the bay window. If the bay window does not meet Package requirements, the project must show compliance under the Performance approach. Bay window fenestration area and orientation in the performance approach is based on each individual window in the bay window.

8.5 Wood Space Heating



WOOD HEATER is an enclosed wood burning appliance used for space heating and/or domestic water heating, and which meets the definition in Federal Register, Volume 52, Number 32, February 18, 1987.



Neither a penalty nor a credit is offered for qualifying wood space heating systems. For compliance with the prescriptive method, you can assume that the heating system has the same performance as Package D, e.g. a gas furnace with an AFUE of 78%, with sealed R-4.2 ducts in the attic. The other measures in the prescriptive package have to be met. For compliance with the performance method, the methodology is described in Chapter 5 (see Table 5-4).

An exceptional method establishes guidelines for use of wood heaters with the *Standards*. The following eligibility criteria apply.

- A. The building department having jurisdiction must determine that natural gas is not available;

Note: Liquefied petroleum gas, or propane, is not considered natural gas.

- B. The local or regional air quality authority must determine that their authorization of this exceptional method is consistent with state and regional ambient air-quality requirements pursuant to Sections 39000 to 42708 of the California Health and Safety Code;
- C. The wood heater must be installed in a manner which meets the requirements of all applicable health and safety codes, including, but not limited to, the requirements for maintaining indoor air quality of the *Uniform Mechanical Code*, in particular those homes where vapor barriers are installed (see Chapter 2);
- D. The wood heater must meet the EPA definition of a wood heater as defined in the Federal Register, Vol. 52, No. 32, February 18, 1987 (see below);
- E. The performance of the wood heater must be certified by a nationally recognized agency and approved by the building department having jurisdiction, to meet the performance standards of the EPA;
- F. The rated output of the wood heater must be at least sixty percent (60%) of the design heating load, using calculation methods and design conditions as specified in §150(h) of the *Standards* (see Chapter 2);
- G. At the discretion of the local enforcement agency, a backup heating system may be required to be installed and be designed to provide all or part of the design heating load, using calculation methods and design conditions as specified in §150(h) of the *Standards*;
- H. The wood heater must be located such that transfer of heat from the wood heater is effectively distributed throughout the entire residential unit or must be used in conjunction with a mechanical means of providing heat distribution throughout the dwelling.

Habitable rooms separated from the wood heater by one free opening of less than 15 square feet or two or more doors must be provided with a positive heat distribution system, such as a thermostatically controlled fan system. Habitable rooms do not include closets or bathrooms.

Wood heaters on a lower level are considered to heat rooms on the next level up, provided, they are not separated by two or more doors.

- I. The wood heater must be installed according to manufacturer and local enforcement agency specifications and must include instructions for homeowners that describe safe operation;
- J. The local enforcement agency may require documentation that demonstrates that a particular wood heater meets any and all of these requirements.

Equipment Criteria

The federal register includes minimum criteria for wood heaters, established by the Federal Environmental Protection Agency. This criteria defines a wood heater as:

... an enclosed, wood burning appliance used for space heating, domestic water heating, or indoor cooking that meets all of the following criteria:

- 1. An air-to-fuel ratio averaging less than 35 to 1,
- 2. Firebox volume less than 20 cubic feet,
- 3. Minimum burn rate less than 5 kilogram/hour (11.0 lbs/hr), and
- 4. Maximum weight of less than 800 kilograms (1762 lbs).

The federal rules explicitly exclude furnaces, boilers and open fireplaces, but include wood-heater inserts.



The Energy Commission's exceptional method for wood heaters with any type of backup heating is available in areas where natural gas is not available. If the required eligibility criteria are met, a building with one or more wood heaters may be shown to comply with the *Standards* using one of the following methods:

Note: Duct efficiency credits may *not* be taken, as the combined wood heater/backup-heating system is assumed to be equivalent to a 78% AFUE central furnace with R-4.2 ducts in the attic.

Prescriptive Approach

The building envelope conservation measures of any one of the Alternative Component Packages must be installed, and the overall heating system efficiency for the wood heater and its backup-heating system may be assumed to be equivalent to that required by the package.

Performance Approach

A computer method may be used for compliance when a home has wood space heat. There is no credit, however. Both the proposed design and the budget building are modeled with the same system, e.g. with the overall heating system efficiency is assumed to be equivalent to a 78% AFUE central furnace with R-4.2 ducts in the attic and diagnostic testing of the ducts.

Note: If all of the criteria for the wood heat exceptional method is not met, the backup-heating system must be included in the compliance calculations as the primary heat source.

Wood Water Heating

Credit is also available for the use of wood heat with water heating systems. See Wood Stove Boilers in Section 6.6.

Example 8-4 – Pellet Stoves

Question

Are pellet stoves treated the same as wood stoves for the purposes of *Standards* compliance?

Answer

Yes.

Example 8-5 – Wall Installed Wood Stove

Question

If a wood stove is installed in a wall, does it have to meet the fireplace requirements of *Standards* §150(e)?

Answer

No. A wood stove that meets EPA certification requirements does not have to meet any requirements applicable to fireplaces.

8.6 Controlled Ventilation Crawl Space (CVC)



Drainage

The Energy Commission has approved an exceptional method for analyzing the energy impact of buildings with raised floors, which use foundation wall insulation and have automatically controlled crawl-space vents. The method is available as an option using an approved computer method with unique modeling criteria explained in Section 5.4.12.

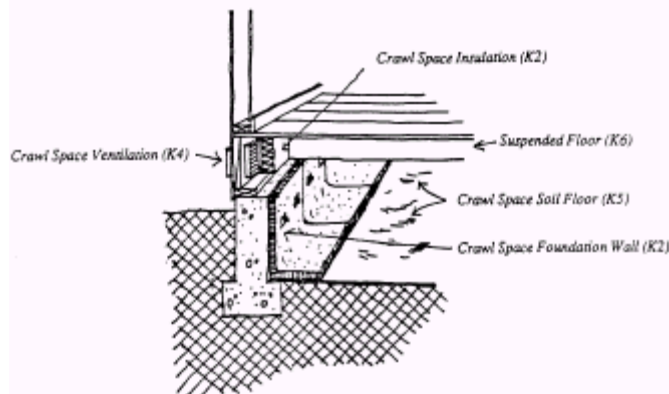
The following steps must be taken, *and the approach must be approved by the local building department*, for the raised-floor building to show compliance with the *Standards* under this exceptional method:

Proper enforcement of site engineering and drainage, and emphasis on the importance of proper landscaping techniques in maintaining adequate site drainage, is critical.

Ground Water And Soils

Local ground water tables at maximum winter recharge elevation should be below the lowest excavated site foundation elevations. Sites that are well drained and that do not have surface water problems are generally good candidates for this stem-wall insulation strategy. However, the eligibility of this alternative insulating technique is entirely at the building officials' discretion. Where disagreements exist, it is incumbent upon the applicant to provide sufficient proof that site drainage strategies (e.g., perimeter drainage techniques) will prevent potential problems.

Figure 8-3 –
Controlled
Ventilation Crawl
Space



Ventilation

All crawl space vents must have automatic vent dampers to receive this credit. Automatic vent dampers must be shown on the building plans and installed. The dampers should be temperature actuated to be fully closed at approximately 40°F and fully open at approximately 70°F. Cross ventilation consisting of the required vent area reasonably distributed between opposing foundation walls is required.

Perimeter Insulation

Foam Plastic Insulating Materials

Foam plastic insulating materials must be shown on the plans and installed when complying with the following requirements:

- **Fire Safety—*UBC* Section 1712(b)2.** Products shall be protected as specified. Certain products have been approved for exposed use in under floor areas by testing and/or listing.
- **Direct Earth Contact—**Foam plastic insulation used for crawl-space insulation having direct earth contact shall be a closed cell water resistant material and meet the slab-edge insulation requirements for water absorption and water vapor transmission rate specified in the mandatory measures.

Mineral Wool Insulating Materials

- **Fire Safety—*UBC* Section 1713(c).** "All insulation including facings, such as vapor barriers or breather papers installed within ... crawl spaces ... shall have a flame-spread rating not to exceed 25 and a smoke density not to exceed 450 when tested in accordance with *UBC*. Standard No. 42-1." In cases where the facing is also a vapor retarder, the facing shall be installed to the side that is warm in winter.
- **Direct Earth Contact—**Mineral wool batts shall not be installed in direct earth contact unless protected by a vapor retarder/ground cover.

Vapor Barrier (Ground Cover)

A ground cover of 6 mil (0.006 inch thick) polyethylene, or approved equal, shall be laid entirely over the ground area within crawl spaces.

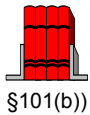
- The vapor barrier shall be overlapped six inches minimum at joints and shall extend over the top of pier footings.
- The vapor barrier should be rated as 1.0 perm or less.
- The edges of the vapor barrier should be turned up a minimum of four inches at the stem wall.
- Penetrations in the vapor barrier should be no larger than necessary to fit piers, beam supports, plumbing and other penetrations.
- The vapor barrier must be shown on the plans and installed.

Studies show that moisture conditions found in crawl spaces that have minimal ventilation do not appear to be a significant problem for most building sites provided that the crawl-space floors are covered by an appropriate vapor barrier and other precautions are taken. The Energy Commission urges building officials to carefully evaluate each application of this insulating technique in conjunction with reduced ventilation because of the potential for adverse effects of surface water on crawl-space insulation that could negate the energy savings predicted by the procedure.

8.7 Zonal Control



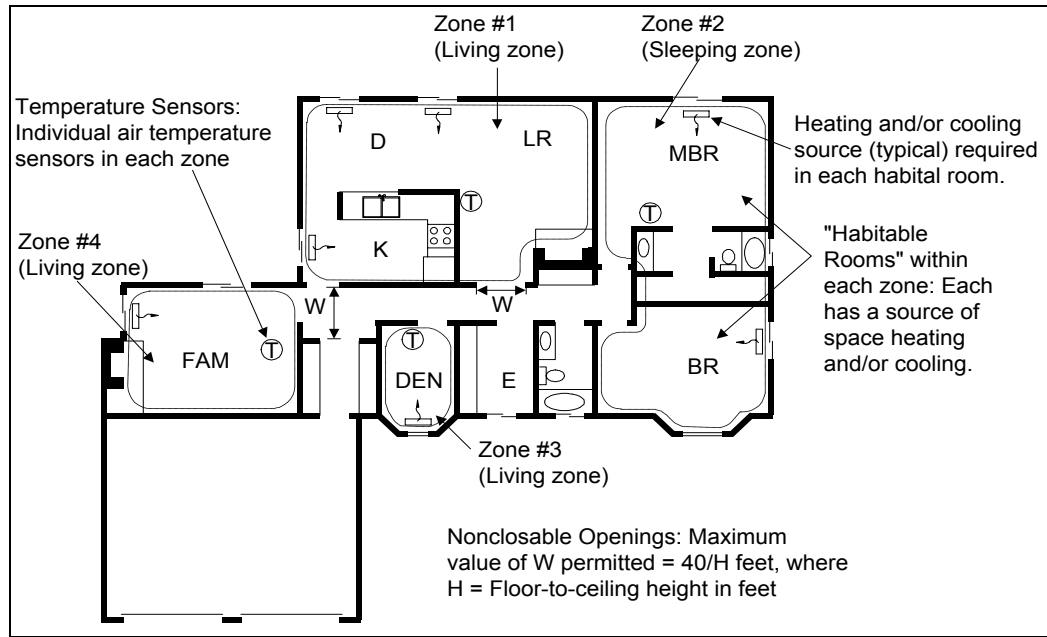
An energy compliance credit is provided for zoned heating and air-conditioning systems, which save energy by providing selective conditioning for only those areas of a house that are occupied. A house having at least two zones (living and sleeping) with separate thermostats controlling temperatures in the zones, and with a maximum non-closeable opening of 40 square feet may qualify for this compliance credit. The equipment may consist of one air-conditioning system for the living areas and another system for sleeping areas or a single system with zoning capabilities, set to turn off the sleeping areas in the daytime and the living area unit turned off at night. (See Figure 8-4).



§101(b))

ZONE, SPACE CONDITIONING is a space or group of spaces within a building with sufficiently similar comfort conditioning requirements so that comfort conditions, as specified in 144(b)3 or 150(h), as applicable, can be maintained throughout the zone by a single controlling device.

Figure 8-4 – Zonal Control Example



Note: Although multiple thermally distinct living and/or sleeping zones may exist in a residence, the correct way to model zonal control credit requires only two zones: one living zone and one sleeping zone. All separate living zone components must be modeled as one single living zone, and the same must be done for sleeping zones.



There are unique eligibility and installation requirements that must be met in order for zonal control to qualify under the *Standards*. The following steps must be taken for the building to show compliance with the *Standards* under this exceptional method:

Temperature Sensors. Each thermal zone, including a living zone and a sleeping zone, shall have individual air temperature sensors.

Habitable Rooms. Each habitable room in each zone shall have a source of space heating and/or cooling (if zonal credit for cooling is desired) such as forced air supply registers or individual conditioning units. Habitable rooms shall not include bathrooms, laundry, halls and/or dressing rooms.

Noncloseable Openings. The total noncloseable opening area between adjacent living and sleeping thermal zones (i.e., halls, stairwells or other openings) shall be less than or equal to 40 square feet. All remaining zonal boundary areas shall be separated by permanent floor to ceiling walls and/or fully solid operable doors capable of restricting free air movement when in the closed position.

Setback Thermostats. Each zone shall be controlled by a central automatic dual setback thermostat that can control the conditioning equipment and maintain preset temperatures for varying time periods in each zone independent of the other.

1. Each zone must have automatic dual setback control for heating, and setup control for cooling if cooling, is provided.
2. Thermostat locations in each zone must provide accurate temperature readings of the typical condition in that zone.
3. The control may be switched from heating to cooling mode manually.
4. The control must be programmable by the occupant.

5. For residences using heat pump systems, the automatic setback thermostat must have two-stage heating which incorporates a recovery ramp of other logic that will minimize electric resistance heating.

Forced Air Ducted Systems

1. Each zone must be served by a return air register located entirely within the zone. Return air dampers are not required.
2. Dampers shall be manufactured and installed so that when they are closed, there is no measurable airflow at the registers.
3. The system must be designed to operate within the equipment manufacturer's specifications.
4. Air is to positively flow into, through and out of a zone only when the zone is being conditioned. No measurable amount of supply air is to be discharged into unconditioned or unoccupied space in order to maintain proper air flows in the system.
5. Systems that allow supply air to be by-passed to the return-air system shall be protected against short cycling and excessive temperatures of the space-conditioning equipment, and include necessary controls for efficient, safe and quiet operation.

*Example 8-6 –
Laundry Room
and Bathroom
Zoning*

Question

In defining the living and sleeping zones for a home with a zonally controlled HVAC system, can laundry rooms and bathrooms (which are not habitable spaces) be included on whichever zone they are most suited to geographically (e.g., a bathroom located near bedrooms)?

Answer

Yes. For computer modeling, include the square footage of any nonhabitable, or indirectly conditioned spaces, with the closest zone.

*Example 8-7 –
Zonal Control
Credit*

Question

I have two HVAC systems and want to take zonal control credit. Can the return air for both zones be located in the hallway (living zone)?

Answer

No. Because of the need to prevent mixing of air between the conditioned zone and the unconditioned zone, it is necessary to (1) have the return air for each zone within that zone, and (2) limit any non-closeable openings between the two zones to 40 square feet or less. Unless these criteria, in addition to the other criteria listed in this Chapter can be met, credit for a zonally controlled system cannot be taken.

8.8 Hydronic/Combined Hydronic Space Heating



Hydronic heating is the use of hot water system as a heat source for space-heating system. Figure 8-5 and Figure 8-6 show simple schematics illustrating some of the components in a hydronic-heating system. A hydronic-heating system consists of five parts.

- The water-heating device, usually the water heater.
- A heat delivery device

- Supply and return piping
- One or more pumps
- Controls

Combined hydronic heating refers to the use of a single water-heating device as the heat source for both space and domestic hot water heating. There are two types of combined hydronic systems. One uses a boiler as a heat source for the hydronic space heating system. The boiler also heats domestic water by circulating hot water through a heat exchanger in an indirect-fired water heater.

The other type uses a water heater as a heat source. The water heater provides domestic hot water as usual. Space heating is accomplished by circulating water from the water heater through the space heating delivery system. Sometimes a heat exchanger is used to isolate potable water from the water circulated through the delivery system. Some water heaters have built-in heat exchangers for this purpose.

There are three main types of hydronic delivery systems, which may be used individually or in combination: baseboard or valence convectors, hot water air handlers, and radiant panel heating systems.

- Baseboard/valence convectors are finned tubes that run along the base or top of walls. A metal enclosure conceals the finned tubes. Convectors do not require ducting.
- Air handlers consist of a blower and finned tube coil enclosed in a sheet metal box, and may be ducted or non-ducted. Air handlers may also include refrigerant coils for air conditioning.
- Radiant panels may be mounted on or integrated with floors, walls, and ceilings. Radiant floor panels are most typical. Tubing for radiant floor systems may be:
 - Embedded in a concrete floor slab
 - Installed over the top of wood sub-floor and covered with a concrete topping
 - Installed over the top of wood sub-floor in between wood furring strips
 - Installed on the underside surface of wood sub-floor

In the latter two types of installations aluminum fins are typically installed to spread the heat evenly over the floor surface, and to reduce the temperature of the water required. All hydronic systems use one or more pumps to circulate hot water. Pumps are controlled directly or indirectly by thermostats, or by special outdoor reset controls.



Complete a DHW-5 worksheet for any project that includes a hydronic space-heating system. This worksheet should accompany all applicable water-heating compliance worksheets. The DHW-5 worksheet is used to determine the effective AFUE for storage gas water heaters and the effective HSPF for storage electric and heat pump water heaters used to supply energy for the combined hydronic space- and water-heating system.

Figure 8-5 –
Hydronic Heating
Heat Distribution
Devices

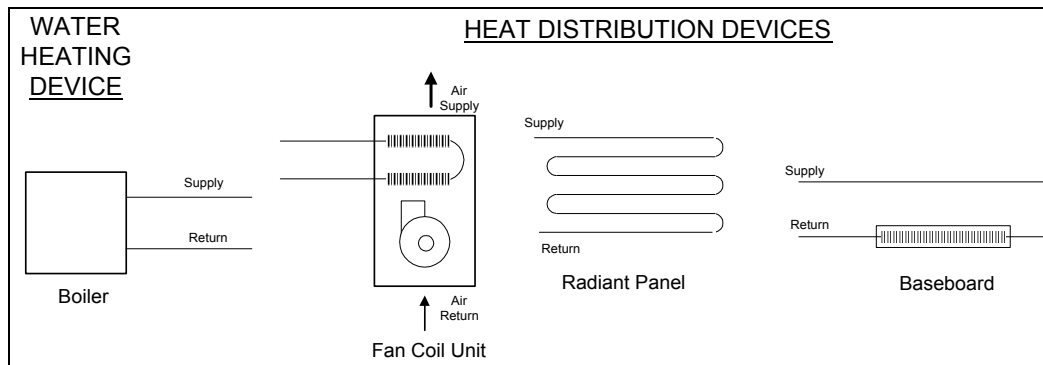
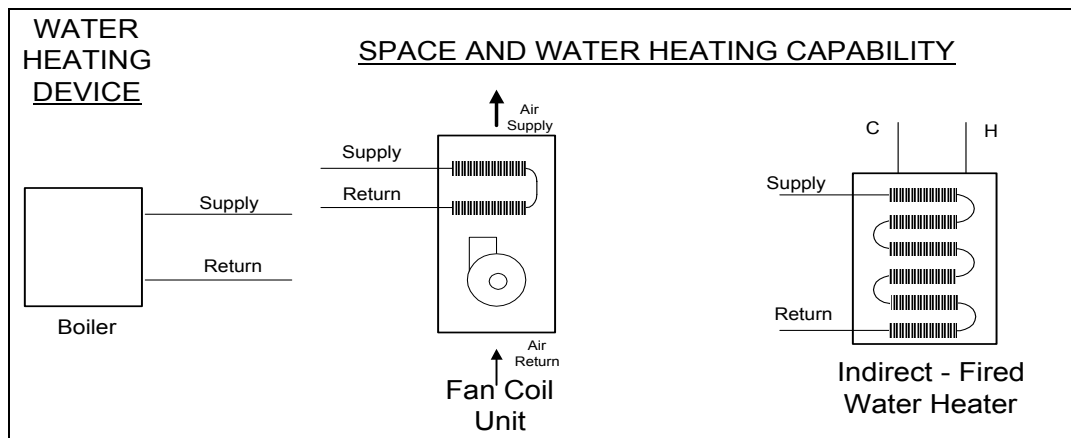


Figure 8-6 –
Space and Water
Heating Capability



Dedicated Hydronic Systems

Dedicated hydronic systems use separate water heating devices for space heating and water heating. For showing compliance of dedicated hydronic systems, the AFUE (for boilers and gas water heaters) or HSPF (for heat pumps), as determined in Section 6.5 (DHW-5), is used. This AFUE or HSPF value is used in the packages or for showing compliance with an energy budget. For water-to-water heat pumps use the following formula: $HSPF = (3.2 \times COP) - 2.4$. Separate compliance for the water-heating system is also required.

Combined Hydronic Space- and Water-Heating Systems

When the hydronic space-heating system serves the additional function of providing domestic hot water (or vice versa), the system is analyzed for its water heating performance as if the space heating function were separate. In other words, treat any hydronic system used for water heating the same as any other water-heating system. Input the correct water heater type, auxiliary input credit (if any) and specify the distribution system.

Compliance

An “effective” AFUE or HSPF rating is used to establish space-heating system efficiency. Refer to Section 6.5 for an explanation of how both water-heating and space-heating system characteristics are accounted for, including the calculation of an Effective AFUE or Effective HSPF rating on the DHW-5 form.

Compliance for a hydronic or combined hydronic-heating system consists of four parts:

1. The water-heating device is typically a boiler or hot water heater, but may be a heat pump.
2. A heat delivery device will be a fan coil, baseboard or radiant panel. Hot water baseboards and radiant panels are normally used for space heating only, and may provide compliance credits since there are no ducts.

3. Supply and return piping.
4. One or more pumps.

Radiant Floor System

One type of radiant panel distribution system is the radiant floor system, where space heating hot water pipes are placed in a concrete slab floor or into a lightweight concrete topping slab laid over a raised floor. These hydronic radiant floor systems in concrete slabs require insulation to be provided between the heated portion of the slab and the outdoors. This insulation may either be slab edge insulation installed from the level of the top of the slab, down 16" or to the frost line, whichever is greater (insulation may stop at the top of the footing, where this is less than the required depth), or heated slab perimeter insulation installed down from the top of the slab and wrapping under the slab for a minimum of 4 feet toward the middle of the slab. The required insulation value for each of these insulating methods is shown in Table 8-1. For performance compliance, the model must assume no insulation is installed, when the insulation levels shown in Table 8-1 are installed. For insulation levels greater than those shown in Table 8-1, the insulation value greater than the value shown in Table 8-1 may be entered into the computer programs for determining the benefits of the additional insulation. Local conditions (such as a high water table) may require special insulation treatment in order to achieve satisfactory system performance and efficiency. To determine the need for additional insulation, follow the recommendations of the manufacturer of the hydronic tubing being installed. Where there is a danger of termite infestation, install termite barriers, as required, to prevent hidden access for insects from the ground to the building framing.

Note: The slab edge insulation required in Table 8-1 is treated as an energy neutral feature. It is not assumed in compliance calculations for credit. R-0 slab edge insulation must be assumed in climate zones 1-15. R-7 must be assumed in climate zone 16.)

Slab edge insulation applied to basement or retaining walls (with slab below grade) should be installed so that insulation starts at ground level and extends down the required distance.

Table 8-1 – Slab Insulation Requirements for Heated Slabs

Climate Zone	Location of Insulation	Orientation of Insulation	Insulation R-Factor	Installation Criteria
1-15	Outside edge of slab, either inside or outside the foundation wall	Vertical	5	From the level of the top of the slab, down 16" or to the frost line, whichever is greater. Insulation may stop at the top of the footing, where this is less than the required depth. For below grade slabs, vertical insulation shall be extend from the top of the foundation wall to the bottom of the foundation (or the top of the footing) or frost line whichever is greater.
16	Outside edge of slab, either inside or outside the foundation wall	Vertical	10	From the level of the top of the slab, down 16" or to the frost line, whichever is greater. Insulation may stop at the top of the footing, where this is less than the required depth. For below grade slabs, vertical insulation shall be extend from the top of the foundation wall to the bottom of the foundation (or the top of the footing) or frost line whichever is greater.
1-15	Between heated slab and outside foundation wall	Vertical and Horizontal	5	Vertical insulation from top of slab at inside edge of outside wall down to the top of the horizontal insulation. Horizontal insulation from the outside edge of the vertical insulation extending 4 feet toward the center of the slab in a direction normal to the outside of the building in plan view.
16	Between heated slab and outside foundation wall	Vertical and Horizontal	10 vertical and 7 horizontal	Vertical insulation from top of slab at inside edge of outside wall down to the top of the horizontal insulation. Horizontal insulation from the outside edge of the vertical insulation extending 4 feet toward the center of the slab in a direction normal to the outside of the building in plan view.

Radiant Floor System/Slab Edge Insulation

When space heating hot water pipes are set into a concrete slab floor, slab edge insulation from the level of the top of the slab, down 16" or to the frost line, whichever is greater (insulation may stop at the top of the footing, where this is less than the required depth), or insulation installed down from the top of the slab and wrapping under the slab for a minimum of 4 feet toward the middle of the slab is required. When space heating hot water pipes are set into a lightweight concrete topping slab laid over a raised floor, any portions of the topping slab directly adjacent to an exterior wall or a retaining wall must have an insulation barrier as shown in Table 8-1 between the topping slab and the exterior of the wall and insulation installed wrapping under the lightweight topping for a minimum of 4 feet toward the middle of the slab. Raised floor insulation that meets the mandatory minimums for wood floor assemblies meets the requirement for insulation wrapping under the lightweight topping slab. Slab edge insulation applied to basement or retaining walls (with slab below grade) must be installed so that insulation starts at or above ground level and extends down the required distance.



Compliance is affected by:

- Water heater or boiler efficiency
- Length of pipe
- Pipe insulation thickness
- Rated input
- Pump Watts (for storage electric).
- Hot water baseboards and radiant panels may provide compliance credits since there are no ducts.
- Slab edge insulation as shown in Table 8-1 must be installed for a hydronic radiant slab floor heating system.

The system will consist of:

1. Water heating device—water heater or boiler.
2. A heat delivery device—fan coil, baseboard or radiant panel.
3. Supply and return piping.
4. One or more pumps.
5. Controls required to operate the system—may include a fan and/or pump relay, distribution system zone valves, boiler return water temperature control, and a delivery water temperature controller.

**Example 8-8 –
Dedicated
Hydronic-heating
System**

Question

My client wants a dedicated hydronic-heating system (space heating only), but a few things are unclear: (1) What piping insulation is required? (2) Can I use any compliance approach? (3) Do I have to insulate the slab with slab edge insulation? and (4) What special documentation must be submitted for this system type?

Answer

- (1) The supply lines not installed within a concrete radiant floor must be insulated in accordance with §150(j)—R-4 on pipes that are 2 inches or less in diameter, R-6 for pipes greater than 2 inches in diameter.
 - (2) You can use any compliance approach; however, when using a prescriptive compliance approach, the AFUE or HSPF (as determined on the DHW-5) must meet the minimum efficiency of the selected Alternative Component Package. NOTE: CALRES requires that a boiler be used as the water heating device for a dedicated hydronic system.
 - (3) The slab edge insulation shown in Table 8-1 is only required when the distribution system is a radiant floor system (pipes in the slab). When this is the case the insulation values shown in Table 8-1 are mandatory measures (no modeling or credit).
 - (4) A DHW-5 worksheet is used to determine the system efficiency (AFUE or HSPF) and must be submitted with other compliance documentation for prescriptive compliance. As noted in Chapter 6, Table 6-2, approved programs perform the water heating calculations internally, so the DHW forms do not need to be submitted.
-

**Example 8-9 –
Slab edge
Insulation
Requirements**

Question

What are the slab edge insulation requirements for a hydronic-heating system with the hot water pipes in the slab?

Answer

The requirements for slab edge insulation can be found in §150(l) and §151(f)1 of the standards and Chapters 2 and 8.

Material and installation specifications:

- Insulation values as shown in Table 8-1
- Protected from physical damage and ultra-violet light deterioration
- Water absorption rate no greater than 0.3% (ASTM-C-271)
- Water vapor permeance no greater than 2.0 per/inch (ASTM-E-96-90)

Modeling assumption:

Do not model or calculate benefits for the insulation levels shown in Table 8-1; they are mandatory requirement for this type of heating system. Instead assume R-0 in climate zones 1 through 15, or R-7 in climate zone 16.

8.9 Evaporative Cooling



Credit for evaporative coolers is allowed in all low-rise residential buildings. Evaporative coolers provide cooling to a building by either direct contact with water (direct evaporative cooler), or a combination of a first stage heat exchanger to pre-cool building air temperature and a second stage with direct contact with water (indirect/direct evaporative cooler).

When selecting evaporative cooling, the following characteristics should be considered:

- Direct evaporative coolers in climates that are both hot and humid may result in uncomfortable indoor humidity levels.
- Indirect/direct evaporative coolers do not increase indoor humidity as much as direct systems, and would be unlikely to produce uncomfortable indoor humidity levels, even in hot, humid areas.
- Evaporative coolers may not reduce indoor temperatures to the same degree as air conditioning.



Evaporative coolers may be used with any compliance approach. Using a performance approach, credit is provided in all low-rise residential buildings. To take the credit, assume that there is a standard central air conditioner (with R-4.2 ducts in the attic) with a SEER rating of 11.0 for direct systems and 13.0 for indirect/direct systems. The same SEERs can be used for evaporative coolers installed with or without backup air conditioning [see multiple HVAC systems in Chapter 5 (computer compliance)].

Ducts from evaporative coolers do not have to be sealed per the prescriptive requirements [§151 (f) 10.], as long as they are not also used by conventional heating or cooling systems.



To receive credit at the efficiencies listed above, the evaporative cooling system must meet the following requirements:

Eligibility and Installation Criteria

1. Evaporative cooler ducts must satisfy all requirements that apply to air conditioner ducts except for diagnostic testing for duct leakage when there is a dedicated duct system for evaporative cooling only.
2. Thermostats are required. If air conditioning is installed in conjunction with an evaporative cooler a two-stage thermostat with time lockout is required.
3. Automatic relief venting must be provided to the building.
4. Evaporative coolers must be permanently installed. No credits are allowed for removable window units.
5. Evaporative coolers must provide minimum air movement at the minimum stated air delivery rate certified with the tests conducted in accordance with the Air Movement and Control Association (AMCA) Standard 210 (see Table 8-2 below).

Table 8-2 –
Minimum Air
Movement
Requirements for
Evaporative
Coolers Minimum
Air Movement¹

Climate Zones	Direct (cfm ft ²)	Indirect/Direct (cfm ft ²)
1 - 9	1.5	1.2
10 - 13	3.2	1.6
14 - 15	4.0	2.0
16	2.6	1.3

¹ If backup air conditioning is installed, the minimum air movement for all climate zones is 1.0 cfm/sf.

8.10 Geothermal (Ground Source) Heat Pump



A geothermal or ground source heat pump uses the earth as a source of energy for heating and as a sink for energy when cooling. Some systems pump water from an aquifer in the ground and return the water to the ground after transferring heat from or to the water. A few systems use refrigerant directly in a loop of piping buried in the ground. Those heat pumps that use either a water loop or pump water from an aquifer have efficiency test methods that are accepted by the Energy Commission. These efficiency values are certified to the Energy Commission by the manufacturer and are expressed in terms of heating Coefficient of Performance (COP) and cooling Energy Efficiency Ratio (EER).



To determine compliance with the residential standards, the COP and EER must be converted to HSPF and SEER

When equipment is not tested for SEER, the EER may be used in place of the SEER. When heat pump equipment is not tested for HSPF, calculate the HSPF as:

Equation 8-1

$$\text{HSPF} = (3.2 \times \text{COP}) - 2.4$$



The efficiency of geothermal heat pump systems is dependent on how well the portion of the system in the ground works. Manufacturer's recommendation must be followed carefully to assure that the system is appropriately matched to the soil types and weather conditions. Local codes may require special installation practices for the ground-installed portions of the system. Verify that the system will meet local code conditions before choosing this type of system to meet the *Standards*.

8.11 Log Homes



Log homes are an alternative construction type used in some parts of the state. Log home companies promote the aesthetic qualities of solid wood construction and can "package" the logs and deliver them directly to a building site. Some companies provide log wall, roof and floor systems with special insulating "channels" or other techniques to minimize the effect of air infiltration between log members and to increase the thermal benefit of the logs alone.

Uninsulated eight-inch solid logs can have an overall thermal resistance equivalent to R-11 insulation (the type of wood is a factor in the R-value). If the wood type of the log is not known, contact the manufacturer to obtain this information.

Note: The mandatory requirement for a minimum of R-13 wall insulation does not apply to unframed walls (e.g., log walls, mass walls).



The thermal mass effects of log home construction can be accounted for within the computer compliance approach (Chapter 5) or prescriptive package C (Chapter 3). Although log walls are not required to be insulated to the level of a framed wall, the effects of the thermal mass (interior and exterior) can compensate for the lack of insulation.

In the computer methods, thermal mass is accounted for when the building envelope is modeled with the specific type of wood (cedar, pine or fir) found in the construction materials section of the computer program. The computer determines the heat capacity of the solid wood/log based upon the wood type and its thickness.

See Chapter 5 and the compliance supplement for the specific computer method being used.

Air infiltration between log walls can be considerably different between manufacturers depending upon the construction technique used. For purposes of compliance, infiltration is always assumed to be equivalent to a wood frame building.

8.12 Straw Bale Construction



In 1995, the California Legislature passed AB1314, a bill that authorizes all California jurisdictions to adopt building codes for houses with walls constructed of straw bales. The bill provided guidelines for moisture content, bale density, seismic bracing, weather protection, and other structural requirements. In order to demonstrate compliance with the *Standards* the Energy Commission, in conjunction with other research and testing facilities, determined the thermal properties needed for compliance. The thermal mass benefit of straw bale construction can only be credited through the use of the computer performance compliance approach by modeling straw bale construction using the heat storage and heat capacity characteristics of the straw bales given below.



Straw bales that are 23 inches by 16 inches are assumed to have a thermal resistance of R-30, whether stacked so the walls are 23 inches wide or 16 inches wide. (Performance data on other sizes of bales was not available at the time of publication of this *Manual*.) The minimum density of load bearing walls is 7.0 pounds per cubic foot, this value or the actual density may be used for modeling straw bale walls in computer compliance approaches. Specific heat is set to 0.32 Btu/lb/°F. Volumetric heat capacity (used in some computer programs) is calculated as density times specific heat (at a density of 7 lb/ft³ the volumetric heat capacity is 2.24 Btu/ft³/°F).



The minimum dimension of the straw bales when placed in the walls must be 22 inches by 16 inches. There are no restrictions on how the bales are stacked.



Due to the higher resistance to heat flow across the grain of the straws, a bale laid on edge with a nominal 16 inch horizontal thickness has the same R-Value (R-30) as a bale laid flat. When the bale is laid flat the nominal horizontal wall thickness is 23 inches but the heat flows along the grain of the straws resulting in the same R-30 thermal resistance for the bale. Thermal performance data on other sizes of bales was not available at the time of publication of this *Manual*.

8.13 Radiant Barriers

See 3.4 Radiant Barriers.